

Comparative evaluation of dimensional accuracy of different polyvinyl siloxane putty-wash impression techniques-in vitro study.

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ABSTRACT

Background: Dimensional accuracy when making impressions is crucial to the quality of fixed prosthodontic treatment, and the impression technique is a critical factor affecting this accuracy. The purpose of this in vitro study was to compare the dimensional accuracy of the casts obtained from one step double mix, two step double mix polyvinyl siloxane putty- wash impression techniques using three different spacer thicknesses (0.5mm, 1mm and 1.5mm), in order to determine the impression technique that displays the maximum linear dimensional accuracy.

Materials & Methods: A Mild steel model with 2 abutment preparations was fabricated, and impressions were made 15 times with each technique. All impressions were made with an addition-reaction silicone impression material (Express, 3M ESPE) and customarily made perforated metal trays. The 1-step putty/light-body impressions were made with simultaneous use of putty and light-body materials. The 2-step putty/light-body impressions were made with 0.5-mm, 1mm and 1.5mm-thick metal-prefabricated spacer caps. The accuracy of the 4 different impression techniques was assessed by measuring 7 dimensions (intra- and inter abutment) (20- μ m accuracy) on stone casts poured from the impressions of the mild steel model. The data were analyzed by one sample 't' test.

Results: The stone dies obtained with all the techniques had significantly larger or smaller dimensions as compared to those of the mild steel model ($P < 0.05$). The order for highest to lowest deviation from the mild steel model was: single step putty/light body, 2-step putty/light body with 0.5mm spacer thickness, 2-step putty/light body 1.5mm spacer thickness, and 2-step putty/light body with 1mm spacer thickness. Significant differences among all of the groups for both absolute dimensions of the stone dies, and their standard deviations from the master model ($P < 0.05$), were noted.

Conclusions: The 2-step putty/light-body impression technique with 1mm spacer thickness was most dimensionally accurate impression methods in terms of resultant casts.

Key Words: accuracy, impression, laboratory research, polyvinyl siloxane, spacer thickness.

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Introduction

Making impressions to replicate oral conditions and tooth morphology is an integral part of prosthetic dentistry.

Polyvinyl siloxane impression materials have the best fine detail reproduction and elastic recovery of all available materials. Because there is no by-product, they possess remarkable dimensional stability and are odorless, tasteless and pleasant for patients. They are provided in wide range of viscosities, rigidities, and working and setting times.

Impression techniques can be categorized as monophasic or dualphase. Techniques that use dual-phase materials such as the putty and light-body may be accomplished in one or two step. The one-step

gingival length of the die was 8 mm. the width of the die is 6mm and the base of the each die was 2 mm in height. Cross grooves were provided on the occlusal surfaces 1mm in depth to serve as reference points for making measurements (Figure 1). The two dies were then welded onto a horizontal metal platform measuring 120mm×40mm. A distance of 28 mm was maintained between the dies at the occlusal level. Two metallic stumps were fixed on either side of the horizontal metal platform for proper orientation of the perforated metal tray. Grooves were made on the platform for the escaping of the light body. A mark was made near the base of one die to recognize the right and left die after pouring the cast.

This was then used as the definitive standardized model for the comparison of the impression



Fig. 1: METAL MASTER MODEL

putty/light-body technique requires less chair-side time. In the two-step putty/ light-body technique, the details are recorded by the light-body material only.¹ The problem of accuracy of impressions has reported that over 89% of the impressions investigated had one or more observable errors^{2,3} Several factors can influence the quality of impressions, including technique⁴⁻⁸ the material^{5,9} the bulk of material^{2,10-12} and others.^{5,13,14}

Therefore the objective of this study was to evaluate the dimensional accuracy of casts obtained from single step and double step polyvinyl siloxane putty wash impression techniques and in the double step impression technique 0.5mm, 1mm and 1.5mm spacer thicknesses were used to evaluate that which one gives maximum linear accuracy.

Materials and Methods

A mild steel master model containing 2 complete-crown, tapered abutment preparations was made. This model had two dies which simulated a clinical crown preparation with 6 degrees total taper. The occluso -

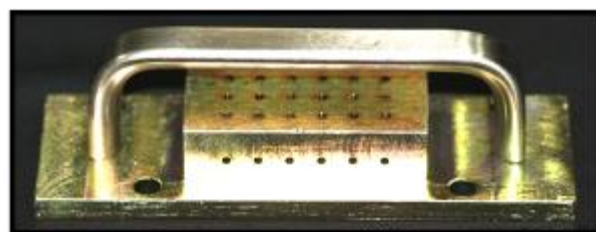


Fig. 2: IMPRESSION TRAY

techniques. All of the impressions were made in customarily made perforated metal trays (Figure 2). These were fabricated maintaining a space of 7 mm for the impression material between the abutment preparation and the inner tray surface. Holes of 2 mm diameter were provided for mechanical retention and a tray adhesive (3M, ESPE VPS) was used. Four holes

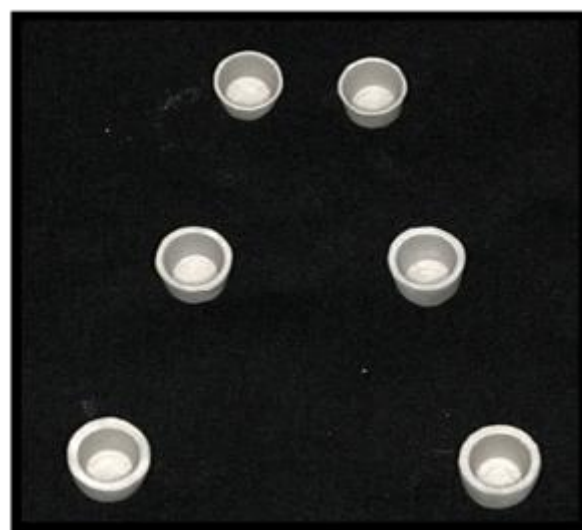


Fig. 3: METAL SPACER CAPS

were provided on the base for proper orientation of the tray during impression making. Metallic spacers were fabricated. 0.5 mm, 1mm and 1.5mm spacer caps were milled in polymethyl methacrylate resin and then they were cast in Ni-Cr alloy (Figure 3). Three wax pattern were fabricated and then were cast in Ni-Cr alloy. All the metallic components were fabricated from mild steel and were chrome plated to avoid rusting. 15 Impressions of the stainless steel model were made for each of the 4 techniques.

Impressions were made with addition-reaction silicone impression material (3M ESPE Seefeld; Germany) Putty (Express™ XT Putty soft) and Light body (Express™ XT Light body)

The putty material was mixed with fingertips until the color was uniform, and all of the other materials were dispensed with an automatic mixing syringe. Care was taken to maintain a working time of three minutes for putty and three and half minutes for light body impression material as recommended by the manufacturer.

All the impressions were allowed to set on the master model for twice the recommended setting time in the mouth. This was in order to compensate for the polymerization occurring at room temperature ($25^{\circ}\text{C} \pm$

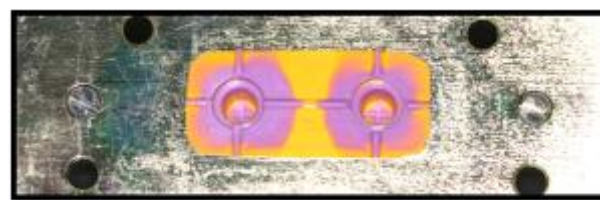


Fig. 4: IMPRESSION

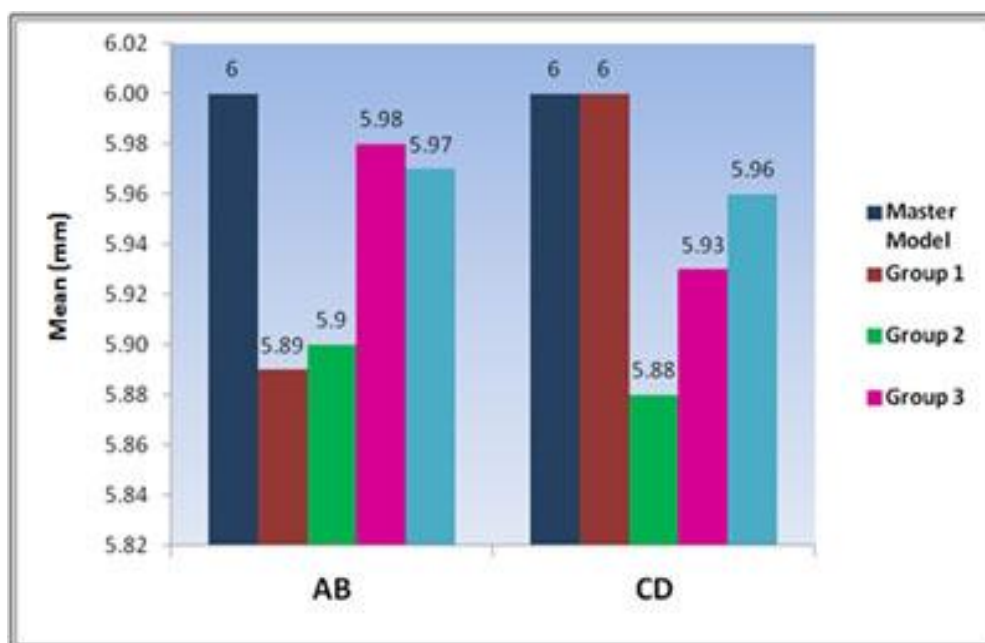
of the tray and the base to confirm exact seating of the tray.

The impressions (figure 4) were poured after thirty minutes simulating clinical situations.

Group I - single step putty light body impression:

Equal quantities of the base and catalyst of putty impression material were mixed and loaded into the tray, while the light body material was injected over the abutment preparations on the master model with the help of mixing gun. Once the light body material was injected, the tray was seated over the master model. All the impressions were allowed to set on the master model for twice the recommended setting time in the mouth (six minutes for putty and light body). Metal to metal contact was established and held in place with gentle finger pressure. (Figure 4)

Group II - two step impression with 0.5 mm of spacer:



Graph 1: Comparison of Mesio-distal distances across all study groups

2°C) rather than mouth temperature ($32^{\circ}\text{C} \pm 2^{\circ}\text{C}$) in accordance with ADA specification No 19.¹⁵⁻¹⁷

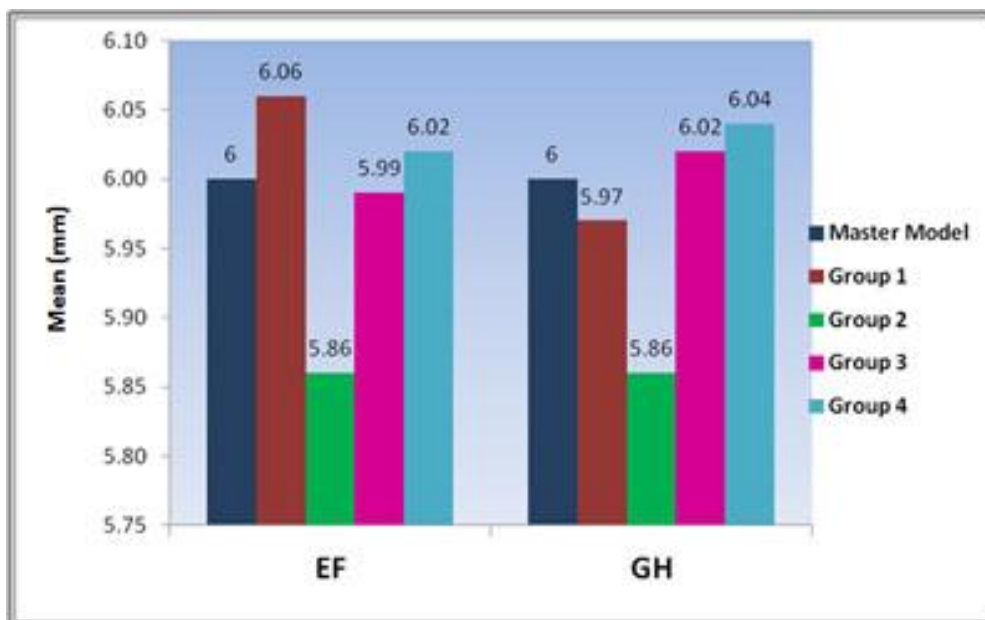
Proper care was taken to check metal to metal contact

0.5mm Ni-Cr spacer caps and the in between spacer plates were placed over the abutments. Equal

quantities of the base and catalysts of putty impression material were mixed and then it was loaded into the tray. This tray was then seated over the master model till the material set. The tray was then removed from the master model, spacer caps and spacer plates were removed from the model and then the light body material was injected over the abutment preparations

with gentle finger pressure.

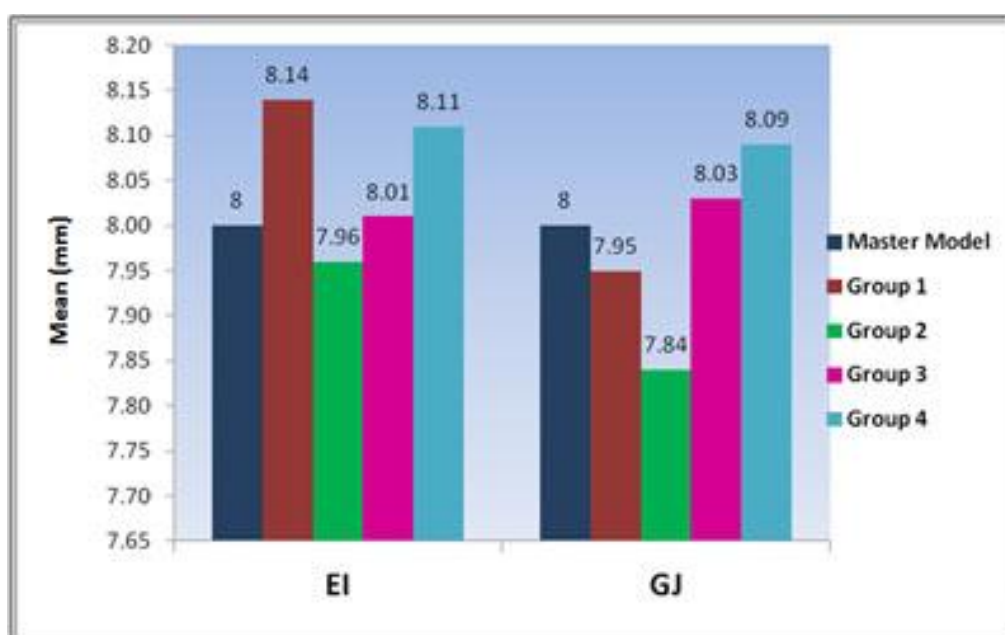
Group III - Two Step Impression with 1mm of spacer thickness: 1mm Ni-Cr spacer caps and the spacer plate were placed over the abutments .Equal quantities of the base and catalysts of putty impression material were mixed and then it was loaded into the impression tray. This tray was then seated over the master model



Graph 2: Comparison of Facio-lingual distances across all study groups

on the master model. Once the light body material was injected, the tray with putty was again seated over the master model. All the impressions were allowed to set

till the material set. The tray was then removed from the master model, spacer caps and spacer plates were removed from the model and then the light body



Graph 3: Comparison of Abutment heights across all study groups

material was injected over the abutment preparations on the master model with the help of mixing gun. Once the light body material was injected, the tray with putty was again seated over the master model. All the impressions were allowed to set with gentle finger pressure.

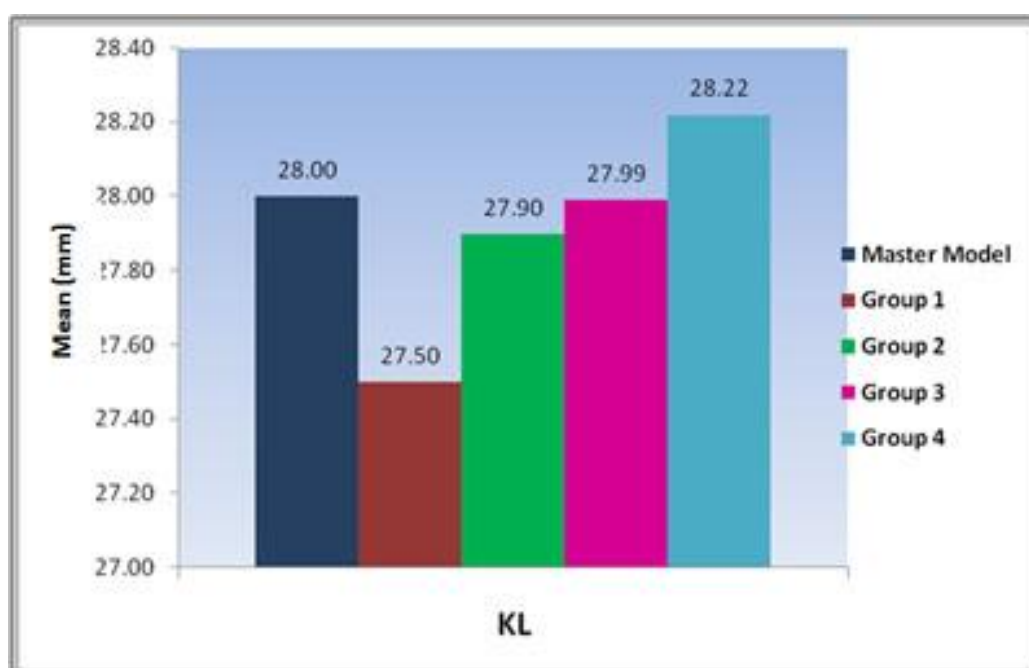
Group IV – Two Step Impression with 1.5 mm of spacer thickness: 1.5mm Ni-Cr spacer caps and the in between spacer plate were placed over the abutments. Equal quantities of the base and catalysts of putty impression material were mixed and then it was loaded into the impression tray. This tray was then seated over the master model till the material set. The

was obtained. This image was then opened with the computer software Rhino 3D and interabutment and intraabutment measurements were made and compared. The measurements of interabutment, abutment height, faciolingual and mesiodistal distances were made.

Mesiodistal Distances

- AB (die 1)
- CD (die 2)

Faciolingual Distances



Graph 4: Comparison of Inter-abutment distances across all study groups

tray was then removed from the master model, spacer caps and spacer plates were removed from the model and then the light body material was injected over the abutment preparations on the master model with the help of mixing gun. Once the light body material was injected, the tray with putty was again seated over the master model. All the impressions were allowed to set with gentle finger pressure.

All the impressions were poured in type IV dental stone. A ratio of 22 ml water: 100 gm die stone was used as recommended. Models were allowed to set for one hour before they were separated. The master models as well as the stone models were laser scanned using laser scanner 'LaserDenta' and the virtual image

- EF (die 1)
- GH (die 2)

Abutment heights

- EI (die 1)
- GJ (die 2)

Inter - abutment distances

- KL (between die 1 and die 2)

All the distances were calculated using Rhino 3D computer software. Each distance was measured three times and the mean value was calculated.

Table 1: Distance measurements for group I stone models

Distances mm							
	AB	CD	EF	GH	EI	GJ	KL
1	5.97762	5.85680	6.03572	5.86542	7.97499	7.84307	26.5487
2	5.51052	6.08229	6.17854	5.65311	8.30443	7.98255	28.0624
3	6.06499	5.88732	6.09281	5.80439	8.10035	7.97720	27.9598
4	5.94223	6.27815	5.91990	6.13215	8.12780	8.02439	28.0936
5	5.99032	5.88920	6.18963	6.22320	8.14860	7.94180	27.8210
6	6.18398	6.02243	6.00506	6.00521	8.10339	7.96698	27.7559
7	5.77024	6.11231	6.12365	6.11234	8.22356	7.94350	27.5678
8	5.84735	6.28821	6.00596	6.12654	8.13356	7.84324	26.7786
9	5.90323	6.30111	6.23476	6.20032	8.30454	7.99789	27.6785
10	5.75213	5.88744	5.92234	5.87765	8.14356	7.88243	27.6574
11	5.84567	5.78922	5.93321	5.67843	7.99432	8.01245	26.5649
12	6.02234	5.82342	5.84532	5.78954	7.90450	8.11485	28.0476
13	5.77601	5.89432	6.12332	6.20001	8.20032	8.00234	27.0956
14	5.93422	6.00223	6.17923	5.86543	8.19876	7.98567	27.8830
15	5.83453	5.88733	6.03847	5.97657	8.23467	7.78365	26.6673

Table 2: Distance measurements for group II stone models

Distances mm							
	AB	CD	EF	GH	EI	GJ	KL
1	5.42432	5.65587	5.91012	5.88653	8.53345	7.84548	28.3080
2	6.20489	5.78957	6.18624	5.96333	8.12327	7.93417	28.0134
3	5.84973	5.46792	5.35663	5.44882	7.62722	7.78130	27.4531
4	5.91784	5.94419	5.91274	5.78489	8.02110	7.83670	27.9266
5	5.73962	5.69516	5.63321	5.90498	7.52361	7.62291	27.9579
6	5.98601	6.04859	5.88921	5.86881	7.88260	7.86280	27.7407
7	5.95678	6.03454	5.87964	5.78956	8.07362	7.84435	27.6009
8	5.93456	6.11345	5.72435	5.98734	7.68894	7.79098	27.8456
9	5.99973	5.98796	5.89735	5.78365	7.88374	7.98976	27.9564
10	6.03345	5.87623	5.88345	5.80038	7.90029	7.60098	28.0134
11	6.00435	5.89364	5.98375	5.72235	8.00294	7.97743	28.2234
12	5.90433	5.85739	5.77839	5.98547	8.17765	7.68976	28.3990
13	5.99032	5.78936	5.90362	5.89684	7.68795	7.89987	27.9665
14	5.83430	6.00983	6.09472	5.97633	8.18874	7.95564	27.8435
15	5.75390	6.02365	5.93649	6.07483	7.97464	8.02234	27.5948

Results

(Table 5) lists the mean of distance measurements across various groups and the distribution of various distance measurements across various groups in

comparison with master model

P-values were obtained by simple 't' test with reference values by master model.

1) Mesiodistal distances (Graph 1):

- 2) Faciolingual distances (Graph 2):
- 3) Abutment heights (Graph 3):
- 4) Inter - abutment distance (Graph 4):
- 5) Overall Group III had relatively better accuracy compared all other study groups.

Discussion:

In the present study, the accuracy of 4 different impression techniques was investigated. Some authors found that there was no difference in accuracy between one step and two step techniques¹⁸ while others

Table 3: Distance measurements for group III stone model

Distances mm							
	AB	CD	EF	GH	EI	GJ	KL
1	6.05129	5.95457	5.95390	6.09805	8.23003	8.00028	27.8785
2	6.02629	6.07012	5.87921	5.91281	7.72664	7.77882	28.1784
3	5.97558	5.94603	6.10066	6.16380	8.07450	8.23214	27.8840
4	5.76936	6.08600	6.04451	6.08952	8.04208	8.11814	27.9617
5	6.00238	5.98876	5.99064	6.01297	8.09023	8.08894	27.9876
6	6.06674	6.09876	5.80982	5.90475	8.00493	8.10020	27.9564
7	5.98947	6.00956	6.00043	6.09474	7.93526	7.97839	27.8990
8	5.90028	5.08764	6.18987	6.06647	8.00385	8.03547	28.0007
9	5.89089	5.96754	5.88986	6.00384	7.89904	8.01435	28.0997
10	6.15544	6.07654	5.93425	6.10001	7.90094	7.99485	27.9954
11	6.03324	6.00934	5.99985	5.99940	8.00036	8.10015	27.9859
12	5.90048	6.00231	5.86758	5.87483	8.16573	7.89905	28.0032
13	5.98867	5.90564	5.99098	5.98894	8.09304	7.99047	28.1023
14	5.95463	5.88976	6.10054	5.99038	7.99040	8.00384	27.9873
15	6.06635	5.90896	6.09087	6.00345	8.00463	8.10023	28.0068

Table 4: Distance measurements for group IV stone models

Distances mm							
	AB	CD	EF	GH	EI	GJ	KL
1	5.88921	6.00751	5.99034	6.10381	8.05479	7.86502	28.3966
2	5.86669	6.06570	6.06251	6.08897	8.01298	8.22569	28.4796
3	6.11167	5.93163	6.04262	6.05183	8.10930	7.95410	28.1173
4	6.08278	6.04180	6.08351	6.04203	8.11898	7.93637	28.0348
5	6.19840	6.06647	5.98894	6.04897	8.08825	8.27748	28.1679
6	5.88930	5.96758	5.86849	6.18947	8.19854	8.16748	28.1238
7	5.78890	6.18894	6.00493	6.03748	8.16673	7.98859	28.3659
8	5.90957	5.78836	6.09948	5.98864	8.18594	8.09937	28.2345
9	5.77839	5.89673	6.13382	5.89304	8.05620	8.09485	28.3567
10	6.05793	5.96734	5.88857	6.04483	7.95720	7.96573	28.0986
11	6.12038	5.79304	5.95738	5.89974	8.00937	8.09526	28.1425
12	6.20027	6.12758	6.04563	5.93829	8.26893	8.14536	28.2456
13	5.99046	6.00348	6.19948	5.99904	8.12837	8.29473	28.3675
14	5.78624	5.70037	6.07586	6.17375	8.14676	8.20293	28.1667
15	5.89937	5.87784	5.87738	6.09375	8.11898	7.96674	28.0756

criticized the one step technique.^{19,20} Disadvantages include lack of control of the bulk of wash material and the high risk of capturing portions of the prepared margin in putty material rather than lower viscosity material. Putty is inadequate for fine detail reproduction.²⁰

This present study was designed to determine the impression technique that displays the maximum linear dimensional accuracy for polyvinyl siloxane putty wash impression technique by assessing the linear dimensional change occurring along the various axes of tooth preparation in a partial arch impression. Thus, the null hypothesis of no difference between the master model and stone models and the accuracy of the four impression techniques was tested at $\alpha=0.05$.

For group I casts, uneven results were obtained. There was decrease in mesiodistal distance of die 1 (AB) by 0.11mm as compared to the master model. The faciolingual distances showed an increase in distance of die 1 (EF) by 0.06mm and decrease in dimension of die 2 (GH) by 0.03mm from the master model. The height of die 1 (EI) was more by 0.14mm than the master model, whereas the height of die 2 (GJ) was smaller by 0.05mm. The inter-abutment distance KL between die 1 and die 2 was found to be less than the master model by 0.50mm which was statistically insignificant.

The putty / wash one step technique for addition silicones was criticized by Chee and Donovan⁹ Clinically, smaller die dimensions would result in castings that are too small or too tight.

In this situation, laboratory procedures should not only compensate for the cement thickness (20 μ m - 40 μ m) and casting shrinkage of metal but also for the decreased width of the die by using a suitable die relief method. In the single step technique, the small amount of variation in the dimension can be compensated by one coat of die spacer which has been shown to vary from 8 μ m - 40 μ m.²¹

For group II casts, the results showed a decrease in the mesiodistal distances (AB, CD) as compared to the master model varying between 0.1mm to 0.12mm. The faciolingual distances (EF, GH) also showed a decrease in dimension from the master model by 0.14mm. Die 1 and die 2 showed a negligible decrease in height (EI, GJ) by 0.04mm and 0.16mm respectively.

Interabutment (KL) distance is decreased by 0.10mm than the master model.

The dies produced were smaller than the master model for all the distances measured. The decrease in the mesiodistal dimension and buccolingual dimension was attributed to the unrestricted polymerization shrinkage of the setting material towards the center of the mass in the interproximal areas.

For group III casts, the results showed a decrease in the mesiodistal distances as compared to the master model varying between 0.02mm and 0.07mm. The faciolingual distance was found to be less than the master model in die 1 (EF) by 0.01mm and increase in die 2 (GH) by 0.02mm. The height of die 1 (EI) and die 2 (GJ) were increased by 0.01mm and 0.03mm respectively. The inter-abutment distances KL between die 1 and die 2 was decrease by 0.01mm.

All the dimensions except for EI and GJ were less compared to master model.

However, even though there was an uneven die size variation, the range of discrepancy from the master model was small. The common observation in group I, II, and III was that the interabutment distance decreased, though there was no statistical significance.

For group IV casts, the results showed a decrease in the mesiodistal distances AB, CD as compared to the master model varying between 0.03mm to 0.04mm. The faciolingual distances (EF, GH) showed an increase in dimension from the master model varying between 0.02mm to 0.04mm. The height of die 1 and die 2 (EI) and (GJ) was found to be more than the master model by 0.11mm to 0.09mm respectively. The inter-abutment distances between die 1 and die 2 (KL) was more than the master model by 0.22mm.

In general, the dies produced were oversized for all the distances measured except for mesiodistal measurements. The dimensional variation may have occurred probably due to the higher thickness of light body.

Our findings show that group III (Table 3) produced the most accurate result in the anteroposterior and vertical dimensions, followed by group IV (Table 4) in the anteroposterior dimension, and group II in the vertical dimension. Group I (Table 1) produced the least accurate results in all dimensions.

The accuracy of group III could be attributed to a

Table 5: The distribution of various distance measurements across various groups in comparison with master model

Distance (mm)	Group I (n=15)			Group II (n=15)		
Mesiodistal distances	Mean (SD)	Model Reference	P-value	Mean (SD)	Model Reference	P-value
AB	5.89 (0.16)	6.0	0.018	5.90 (0.18)	6.0	0.049
CD	6.00 (0.17)	6.0	0.998	5.88 (0.17)	6.0	0.018
Faciolingual distances	Mean (SD)	Model Reference	P-value	Mean (SD)	Model Reference	P-value
EF	6.06 (0.12)	6.0	0.089	5.86 (0.19)	6.0	0.017
GH	5.97 (0.19)	6.0	0.522	5.86 (0.15)	6.0	0.003
Abutment heights	Mean (SD)	Model Reference	P-value	Mean (SD)	Model Reference	P-value
EI	8.14 (0.11)	8	0.001	7.96 (0.26)	8	0.490
GJ	7.95 (0.08)	8	0.050	7.84 (0.13)	8	0.001
Inter - abutment distances	Mean (SD)	Model Reference	P-value	Mean (SD)	Model Reference	P-value
KL	27.5 (0.58)	28	0.004	27.9 (0.26)	28	0.274

controlled amount of bulk of impression material, adhesive systems and low polymerization contraction with the heavy-body material.

Conclusion:

1. The two step double mix putty wash impression technique with 1mm of spacer yielded casts that showed the least dimensional variation as compared to the single step putty wash impression technique.
2. One step putty wash impression technique produced casts that showed the greatest dimensional variation in all the distances, compared to all the groups.

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